MAGNETIC CORE MULTIVIBRATOR CIRCUIT

Filed Nov. 1, 1957

FIG. 1

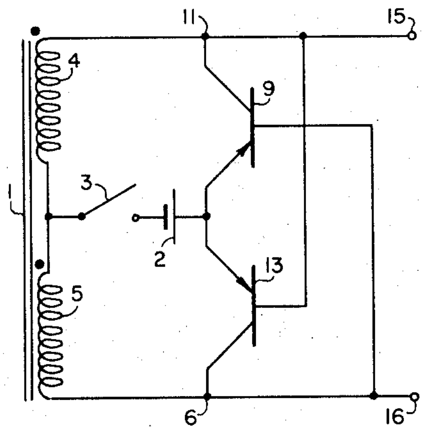


FIG. 2

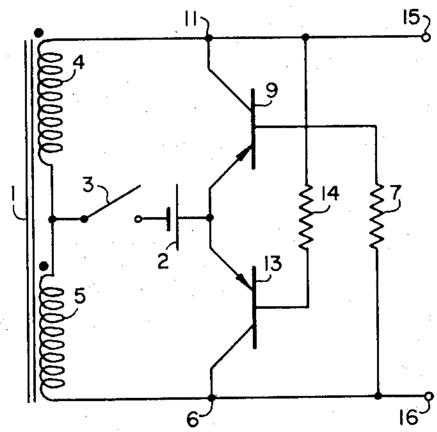


FIG. 3

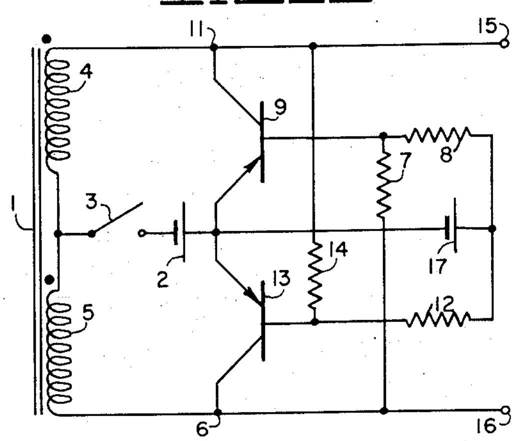
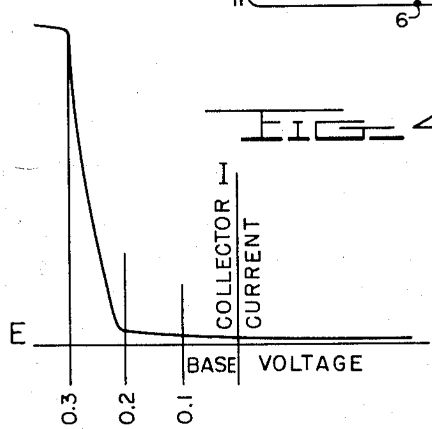


FIG. 4



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MAGNETIC CORE MULTIVIBRATOR CIRCUIT

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to electronic circuits and more particularly to a multivibrator circuit including a magnetic core and transistors.

Reduction of the number of components in a multivibrator has long been a goal in the art. Some prior art multivibrators using magnetic cores require many core windings in order to enable the circuit to operate properly. In other prior circuits, it was either inconvenient or impossible to wind the necessary turns on the core. In still other prior circuits, difficulty is encountered in starting the oscillation of the circuit.

It is therefore, an object of this invention to provide an efficient multivibrator composed of a minimum number of components.

Another object is to provide a multivibrator wherein oscillation is easily started.

A still further object of this invention is to provide a magnetic core multivibrator requiring only a single winding on the core.

Another object is to provide a magnetic core multivibrator circuit requiring a small number of winding turns on the core.

These and other features of the invention, as well as additional objects therefor, will become apparent by reference to the ensuing description and the accompanying drawings in which:

Fig. 1 is a schematic diagram of an embodiment of the magnetic core multivibrator circuit of this invention.

Fig. 2 is a schematic diagram of a second embodiment of the circuit of this invention.

Fig. 3 is a schematic diagram of a third embodiment of the circuit of this invention.

Fig. 4 is a graphic showing of the relationship of the base voltage to the collector current for the transistors used for switching purposes in this invention.

In accordance with the basic teachings of the present invention, a simplified multivibrator circuit is provided requiring as essential elements a coupling transformer, two transistors and a suitable relatively simple power source. The coupling transformer comprises a single center tapped winding placed upon a core composed of high remanence material having "square-loop" hysteresis characteristics. A core composed of such material, which is somewhat similar to a permanent magnet in certain of its characteristics, can be driven to saturation in either of two polarities by a suitable driving signal applied to a winding thereon. Upon removal of this driving signal, however, the core does not return to an unmagnetized condition, as does ordinary transformer core material, for example, but assumes a condition of magnetism somewhat lower than saturation, called: remanence, which is thereafter retained indefinitely or until forceably removed by a driving signal of opposite polarity to that of the original driving signal. It is this "slip-back" from saturation to remanence that is employed in a novel way in the circuit of the present invention to produce the alternate triggering of the transistors to produce the familiar multivibrator action.

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The invention as shown in Fig. 1 includes a magnetic core **1** with a center tapped winding thereon. The center tap is connected to the negative side of power supply **2** through switch **3**. The positive side of the power supply **2** is connected to a first junction point to which are connected the emitters of transistors **9** and **13**. The collector of transistor **9** is connected to junction **11** to which also are connected the dotted end of winding **4**, which is one-half of the center tapped winding, and the base of transistor **13**. The collector of transistor **13** is connected to junction **6** to which also are connected the not-dotted end of winding **5**, which is the other half of the center tapped winding, and the base of transistor **9**. Also included in the circuit are output terminals connected across the center-tapped winding on the magnetic core **1**.

To better understand the operation of the circuit as shown in Fig. 1, it is assumed that core **1** is initially at negative remanence before the application of the power from the power source **2**. A positive magnetizing force is needed to change the state of core **1** from negative remanence to positive saturation. By convention, positive current entering a dotted end of a core winding induces positive magnetizing force in the core. The negative side of the power source **2** is applied to the junction of windings **4** and **5** which are halves of a single center tapped winding. With the core in a condition of negative remanence, winding **4** is capable of changing the core flux alignment to positive saturation. As set forth above, if the core **1** is initially at negative remanence, when the switch **3** is closed, the flux alignment will change toward positive saturation. A negative potential is induced across winding **5** which, combined with the negative potential of the power source **2**, when applied through junction **6** to the base of p-n-p transistor **9**, causes transistor **9** to be conductive. Current will then flow from the positive side of power source **2** through transistor **9**, junction **11**, winding **4** and switch **3** to the negative side of power source **2**. During this current flow through transistor **9** and winding **4**, core **1** is driven from negative remanence to positive saturation. Transistor switch **13** is held in the off state due to the fact that the combined potential from the battery **3** and winding **4** is not enough for conduction as witnessed by Fig. 4 as discussed below.

When the condition of core **1** reaches positive saturation, the negative potential induced across winding **5** disappears and transistor switch **9** cuts off. The drop from flux saturation to remanence in the core, upon the blocking of transistor **9**, induces a negative signal which is applied to the base of transistor **13**. This negative signal turns transistor switch **13** on and current will then flow from the positive side of power source **2** through transistor **13**, junction **6**, winding **5** and switch **3** to the negative side of power source **2**. During this current flow through transistor **13** and winding **5**, core **1** is driven to negative saturation.

When the condition of core **1** reaches negative saturation, the negative potential induced across winding **4** disappears and transistor switch **13** cuts off. The "slip-back" from saturation to remanence upon the opening of transistor switch **13** induces a negative signal across winding **5** which is applied to the base of transistor **9**. This negative signal turns transistor switch **9** on and current will then flow from the positive side of the power source **2** through transistor switch **9**, junction **11**, winding **4**, and switch **3** to the negative side of power source **2**.

As in a typical two state multivibrator, it is seen that in the first state, transistor **9** is conductive and transistor **13** is non-conductive. In the second state, transistor 9 is non-conductive and transistor 13 is conductive.

The circuit will continue to operate with the flux alignment of the core being reversed automatically by the selective operation of the transistors until such time that the power source is disconnected from the circuit.

A typical output is provided so that an output of square wave characteristics can be obtained across terminals 15 and 16.

The circuit shown in Fig. 2 differs from the circuit of Fig. 1 only by the addition of current limiting resistors 14 and 7. Resistors 14 and 7 are added should the values of the components require such resistance to limit the current that is available to the transistors.

The circuit of Fig. 3 differs from the circuit of Fig. 1 by the addition of the current limiting resistors 14 and 7 found also in Fig. 2, by the addition of the biasing battery 17 which is added to assure that the transistor which should be non-conductive is completely non-conductive, and by the addition of the voltage divider resistors 8 and 12. Resistors 8 and 12 limit the increased biasing current provided by battery 17 to increase proper switching control.

Fig. 4 shows the relationship of collector current with respect to voltages applied to the base thereof when the collector load resistance is constant. The particular curve is the curve of a p-n-p type number 2N128 transistor which is typical of the transistors which are usable in this invention. Particular transistors are selected which have values which meet circuit requirements. As the curve in Fig. 4 indicates, a small amount of current leakage occurs when a voltage is applied to the base of the transistor. When the voltage applied to the base is in the range between minus 0.2 and 0.3 volt, current will flow freely through the collector of the transistor. The amount of current which will flow reaches a maximum when the base voltage is about minus 0.3 volt as the transistor will become saturated and can pass no more than said maximum current. It is this "built-in" bias characteristic of the transistors to maintain the transistors in the non-conductive condition even though the base voltage is slightly negative which allows the circuit to operate properly without the addition of biasing components.

In a typical circuit as shown in Fig. 2, core 1 is made of 79% nickel, 4% molybdenum, and the balance is iron. The center tapped winding has a total of 400 turns. The power source 2 is a 3 volt battery. The transistors 9 and 13 are p-n-p type number 2N128 and the resistors 7 and 14 are 1,000 ohms each. In Fig. 3, biasing source 17 could be a 1½ volt battery.

It is obvious that the polarity of the battery can be reversed and n-p-n transistors can be used.

It is seen that I have provided a very compact and efficient multivibrator circuit with a minimum number of components. The multivibrator of this circuit is very easily set into oscillation. Under severe loading of the output, the voltage drops across the halves of the center tapped winding might, rarely, be equal; however, oscillation can be started by merely touching one of the halves, or by any means that will provided a slight inductive change in one of the halves. Also, in this multivibrator, the only winding is center tapped, a feature which minimizes the problems of providing windings on the core.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a multivibrator, a magnetic core, a winding on said core having first and second ends and a center terminal, a power source including positive and negative terminals, means connecting said center terminal to said negative terminal, a first transistor having a collector, a base and an emitter, a second transistor having a collector, a base and an emitter, means connecting said emitters

of said first and said second transistors to the said positive terminal, means connecting said first end of said winding to the collector of said first transistor and to the base of said second transistor, means connecting said second end of said winding to the collector of said second transistor and to the base of said first transistor.

2. In an electronic circuit, a magnetic core, a winding on said core having first and second ends and a center terminal, a power source including first and second terminals, means connecting said center terminal to said first terminal, a first transistor having a collector, a base and an emitter, a second transistor having a collector, a base and an emitter, means connecting said emitters of said first and said second transistors to the said second terminal, means connecting said first end of said winding on said core to the collector of said first transistor and to the base of said second transistor, means connecting said second end of said winding on said core to the collector of said second transistor and to the base of said first transistor.

3. In a multivibrator, a magnetic core, a winding on said core having first and second end connections and a center connection, a power source including two terminals, means connecting said center connection to one of said terminals, first and second transistors each having a collector, a base and an emitter, means connecting said emitters to the other of said terminals, means connecting said first end connection at a first junction to the collector of said first transistor and the base of said second transistor, and means connecting said second end connection at a second junction to the collector of said second transistor and the base of said first transistor.

4. The multivibrator of claim 3 wherein said means for connecting said first end connection at a first junction to the base of said second transistor includes a first current limiting resistor and wherein said means for connecting said second end connection at a second junction to the base of said first transistor includes a second current limiting resistor.

5. The multivibrator of claim 4, circuit divider means including third and fourth resistors each having two leads, means connecting one lead of said third resistor between the base of the first transistor and the second current limiting resistor, means connecting one lead of said fourth resistor between the base of the second transistor and the first current limiting resistor, means connecting said other lead of said third and said fourth resistors to a common junction, biasing source means including third and fourth terminals, means connecting said third terminal to said common junction and means connecting said fourth terminal to said means connecting said emitters.

6. In a multivibrator, a magnetic core, a winding on said core having first and second end connections and a center connection, a power source including positive and negative terminals, means connecting said center connection to said negative terminal, a first transistor and a second transistor, each of said transistors being of the p–n–p type, each having a collector, a base and an emitter, means connecting said emitters to said positive terminal, means connecting said first end connection at a first junction to the collector of said first transistor and the base of said second transistor, and means connecting said second end connection at a second junction to the collector of said second transistor and the base of said first transistor.

7. The multivibrator of claim 6 wherein said means for connecting said first end connection at a first junction to the base of said second transistor includes a first current limiting resistor and said means for connecting said second end connection at a second junction to the base of said first transistor includes a second current limiting resistor.

8. The multivibrator of claim 7 including circuit divider comprising two resistors, one end of a first circuit divider

resistor means is connected to a point between the base of said first transistor and second current limiting resistor, one end of a second circuit divider resistor means is connected between the base of said second transistor and said first current limiting resistor, means connecting the other end of said circuit divider resistors at a third junction, biasing source means, means connecting said biasing source means to a third junction and to the means connecting said emitters to the other of said terminals.

9. In a multivibrator, a magnetic core having rectangular hysteresis loop characteristics, a winding on said core having first and second ends and a center terminal, a power source including positive and negative terminals, means connecting said center terminal to said negative terminal, a first transistor having a collector, a base and an emitter, a second transistor having a collector, a base and an emitter, means connecting said emitter of said first and said second transistors to the said positive terminal, means connecting said first end of said winding to the collector of said first transistor and to the base of said second transistor, means connecting said second end of said winding to the collector of said second transistor and to the base of said first transistor.

10. In an electronic circuit, a magnetic core having rectangular hysteresis loop characteristics, a winding on said core having first and second ends and a center terminal, a power source including first and second terminals, means connecting said center terminal to said first terminal, a first transistor having a collector, a base and an emitter, a second transistor having a collector, a base and an emitter, means connecting said emitters of said first and said second transistors to the said second terminal, means connecting said first end of said winding on said core to the collector of said first transistor and to the base of said second transistor, means connecting said second end of said winding on said core to the collector of said second transistor and to the base of said first transistor.

11. In a multivibrator, a magnetic core having rectangular hysteresis loop characteristics, a winding on said core having first and second end connections and a center connection, a power source including two terminals, means connecting said center connection to one of said terminals, first and second transistors each having a collector, a base and an emitter, means connecting said emitters to the other of said terminals, means connecting said first end connection at a first junction to the collector of said first transistor and the base of said second transistor, and means connecting said second end connection at a second junction to the collector of said second transistor and the base of said first transistor.

12. In a multivibrator, a magnetic core having rectangular hysteresis loop characteristics, a winding on said core having first and second end connections and a center connection, a power source including positive and negative terminals, means connecting said center connection to said negative terminal, a first transistor and a second transistor, each of said transistors being of the p–n–p type, each having a collector, a base and an emitter, means connecting said emitters to said positive terminal, means connecting said first end connection at a first junction to the collector of said first transistor and the base of said second transistor, and means connecting said second end connection at a second junction to the collector of said second transistor and the base of said first transistor.

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Disclaimer

2,963,658.—*Robert W. Rochelle*, Alexandria, Va. MAGNETIC CORE MULTIVIBRATOR CIRCUIT. Patent dated Dec. 6, 1960. Disclaimer filed Mar. 22, 1963, by the inventor.

Hereby enters this disclaimer to claims 2 and 10 of said patent.

[*Official Gazette September 3, 1963.*]

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